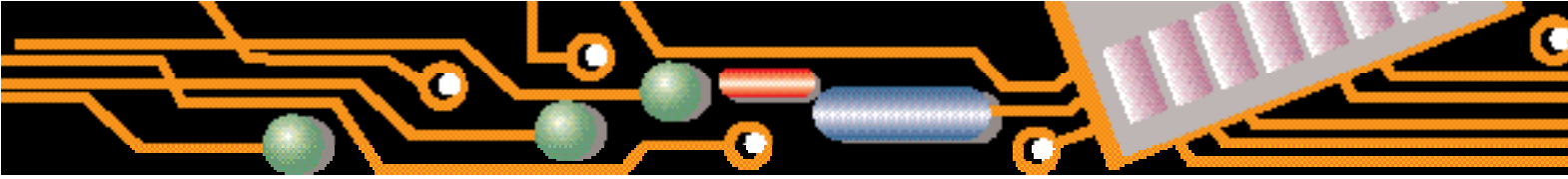
Part Two -
Background and Program Status

Strategic Plan
for Scottsdale

Intelligent Transportation Systems

April 2004



Objectives of Scottsdale ITS:

- Hold travel time on City streets steady, and where possible, reduce travel time, even as traffic volume increases due to growth.

- Reduce traffic incident delay.

- Communicate rapidly among Police Department, Emergency Services, Arizona Department of Transportation, Fire, vehicle drivers and Traffic Management Center to enhance roadway safety.

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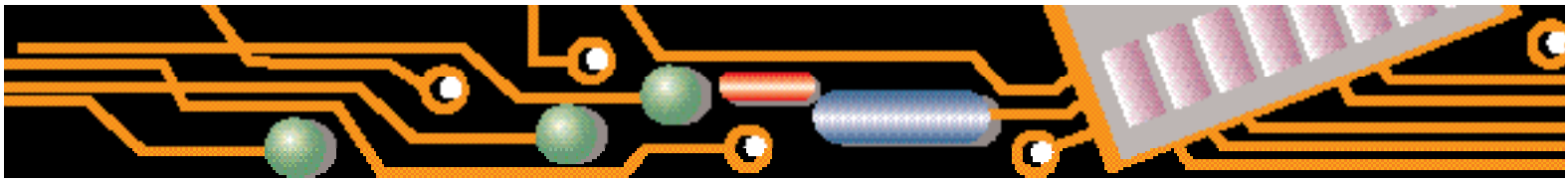


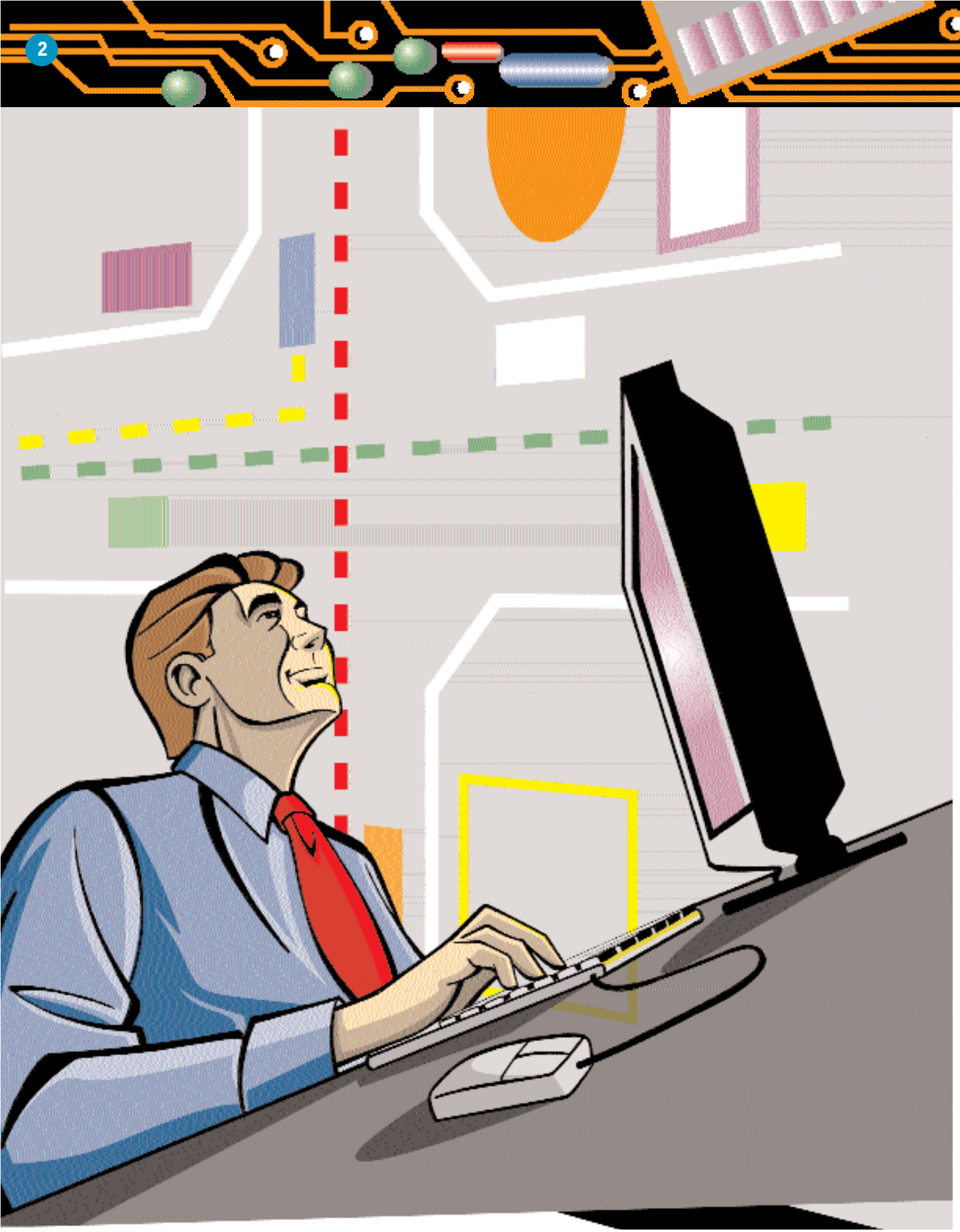
PART II Background and Program Status

Purpose of the Scottsdale Strategic Plan for Intelligent Transportation Systems

This document is Part II of a Strategic Plan for deploying, operating and maintaining high technology in advanced arterial traffic management in the City of Scottsdale. Part I of the Plan summarizes the results of the planning process and sets out the goals, objectives, strategies, and achievement challenges for Intelligent Transportation Systems (ITS) in Scottsdale advanced traffic management.

Parts I and II of the Strategic Plan are available on the City of Scottsdale website www.ScottsdaleAZ.gov, keywords *traffic management*, or by request.

Questions regarding the Scottsdale ITS Strategic Plan should be directed to the Scottsdale Transportation Department, Janet Secor, (480) 312-2389, jsecor@ScottsdaleAZ.gov.



What Is ITS?

Intelligent Transportation Systems, or ITS, is the implementation and management of advanced traffic surveillance, signal and control systems to improve the safety and efficiency of roadways. ITS deployment and operation requires new traffic management skills in systems engineering, electronics and communications.

ITS technologies include traffic signals, computers, integrated software systems, graphics, video walls, fiber optic cable, Closed Circuit TV Cameras (CCTVs), wireless equipment, variable message signs (VMS), ramp meters, and vehicle detectors.

One key goal of ITS is to enable drivers to move as quickly as possible throughout Scottsdale and the Valley by increasing the theoretical capacity of existing streets.

Key Concept: *theoretical capacity, defined as the maximum number of vehicles that a roadway, section of roadway or intersection, ideally could handle.*

Scottsdale ITS devices are integrated with a central coordinated electronic traffic signal system. Devices are linked to a Traffic Management Center (TMC) in the One Civic Center building, where traffic management professionals manage and operate the system using real-time information. ITS includes links to Scottsdale Police Department, the Arizona Department of Transportation (ADOT), and the Rural/Metro Fire Department. ITS also supports the nationwide "Amber Alert" program for public notification of kidnapped children, and aids Homeland Security and natural disaster support efforts.

ITS provides City traffic engineers with tools to efficiently develop new signal timing plans and to deal with road closures, accidents and special events in a timely and effective manner. Staff using these tools can increase the through-put capacity of Scottsdale streets, and lessen the impacts of serious accidents or roadway restrictions on the traveling public.

Overview of Scottsdale Advanced Traffic Management

In one sense, Scottsdale installed advanced traffic management with its first electronic traffic signal system in the 1980s. After receipt of a federal grant for ITS Model Deployment Initiative, Scottsdale intensified planning for ITS in the mid-1990s. Participation in the Initiative was premised on the idea that, through technology, staff could maximize the efficiency of existing streets and freeway systems, knowing that the addition of more lanes or new freeway miles may not be politically or economically feasible in the future. The ITS program was planned to include five elements, or technology subsystems: CCTVs, video detection, VMS, TMC, and regional interface. Those are the systems being deployed in 2004.

Since 1997, the City has invested $5.2 million in ITS infrastructure over and above traffic signal construction. Another $12.6 million is planned on the ITS fiscal year 2004-08 Capital Improvement Plan. The communications infrastructure for ITS devices consists of both hardwire/fiber lines leased from private companies and City-owned fiber infrastructure. Data from each of the signals, vehicle detection devices, and CCTVs is brought back to the TMC via the communication lines and displayed on a video wall. All of the controls for the devices are housed in the TMC. Traffic engineers control devices at the TMC console.

ITS technology benefits traffic management most effectively when tools are employed by sufficient, competent staff, a key ITS component. In fiscal year 2003/04, the City budgeted $1.6 million to operate and maintain the ITS-enabled traffic management system, mostly in the Municipal Services Department. The Municipal Services Department spends $1.1 million annually to provide electricity to and to maintain the traffic signals. The Transportation Department spends about $500,000 a year to manage traffic and signalization, and to operate and maintain the TMC.

At inception of the ITS-enabled traffic management initiative, two traffic signal analysts staffed TMC. These staff remain with the program as ITS analysts. In 2000, a new position, ITS Technician, was created and filled by a new hire. Staff report directly to the Traffic Engineering Director.

Listed below are milestones in Scottsdale ITS deployment:

- Traffic Signal Management System, Transcore/JHK Series 2000 System (ATMS) for central control of signals, implemented in October 1993, enabling efficiencies in signal synchronization.

- Computer server to connect to the regional ITS network administered by Maricopa County Department of Transportation (called AZTech) installed in 1997 in the TMC.

- Transcore 2000 hardware and software significantly upgraded in 1999.

- TMC construction completed and fully operational in 2001.

- The City's first ITS corridor operational along Indian School Road in August 2002.

Scottsdale Partners in ITS Policy and Practice Decisions

Scottsdale ITS is integrated across Maricopa County by a regional coordination and communication network so that jurisdictions manage traffic on the roadways in a coordinated fashion. At an even higher level, ITS is coordinated across the country as envisioned by the U.S. Department of Transportation, Federal Highway Administration (FHWA). As a result, policy and practice decisions about ITS at the City involve three levels of government: local, regional, and federal.

The Challenge of Managing Scottsdale Traffic

In 2003, Scottsdale has over 23 million square yards of asphalt, 1,400 lane miles of striping, and 260 signalized intersections. The City has three major north/south streets and one paralleling freeway, the Pima Freeway, to handle commercial, retail and light industrial traffic, as well as about 220,000 residents.

Prior to the opening of the Pima Freeway along Scottsdale's north and east boundary in April 2002, each of Scottsdale's major corridors was at, or over, capacity. Even minor street disruptions, such as accidents, lane closures or other delays, caused extended delays to the traveling public. TMC staff respond to an estimated 700 to 800 such incidents annually. The full opening of Pima Freeway provided measurable relief to many of the busiest streets. The relief, however, has been short-lived. In areas of the City inside the Pima Freeway Loop, traffic congestion will be managed by means of ITS.

ITS Enhancements to Traffic Management Are Measurable

The benefits of managing traffic congestion with ITS can be measured. A key measure of traffic management effectiveness is the metric termed Level of Service, or LOS.

Key Concept: *Level of service of intersections. Includes measurement of signalized intersection performance in terms of average seconds of delay per driver.*

The LOS metric for intersection performance is structured like a school report card. "A" is good LOS, "F" is bad LOS. The actual LOS units vary slightly depending upon what is being measured. Most often, traffic engineers are measuring signalized intersection performance in terms of average seconds of delay per driver. The LOS scale used by Scottsdale, and the delays entailed, are shown in the table below.

Level of Service - Intersection	Seconds of Delay per Vehicle
A	Less than 5 seconds
B	From 5 to 15 seconds
C	From 15 to 25 seconds
D	From 25 to 40 seconds
E	From 40 to 60 seconds
F	Greater than 60 seconds

The City's current working LOS goal is D or better. However, an active program of periodic LOS measurements has not been restarted in the Department, due to resource constraints in the face of changing priorities. The most recent LOS report is from 1997. A report is due in the Winter of 2003. According to staff, 15 of the 30 intersections last studied (of 260 total intersections) were LOS F.

ITS-enabled traffic management has the potential to mitigate increasing delays by increasing traffic movement efficiency on Scottsdale streets. ITS allows TMC and Police Department personnel to control signal timing quickly and remotely, and to disseminate delay information to drivers.

In addition to facilitating signalization and management of incidents and special events, ITS provides TMC engineers with traffic volume data. Traffic volume data is useful to transportation planners to better determine traffic impacts from development. Traffic volume data also provides a gauge of how well Scottsdale streets are performing. If traffic on a roadway is traveling at the posted speed limit with high volumes of traffic, the roadway is performing at, or better than capacity.

What Benefits Have Been Gained from ITS So Far?

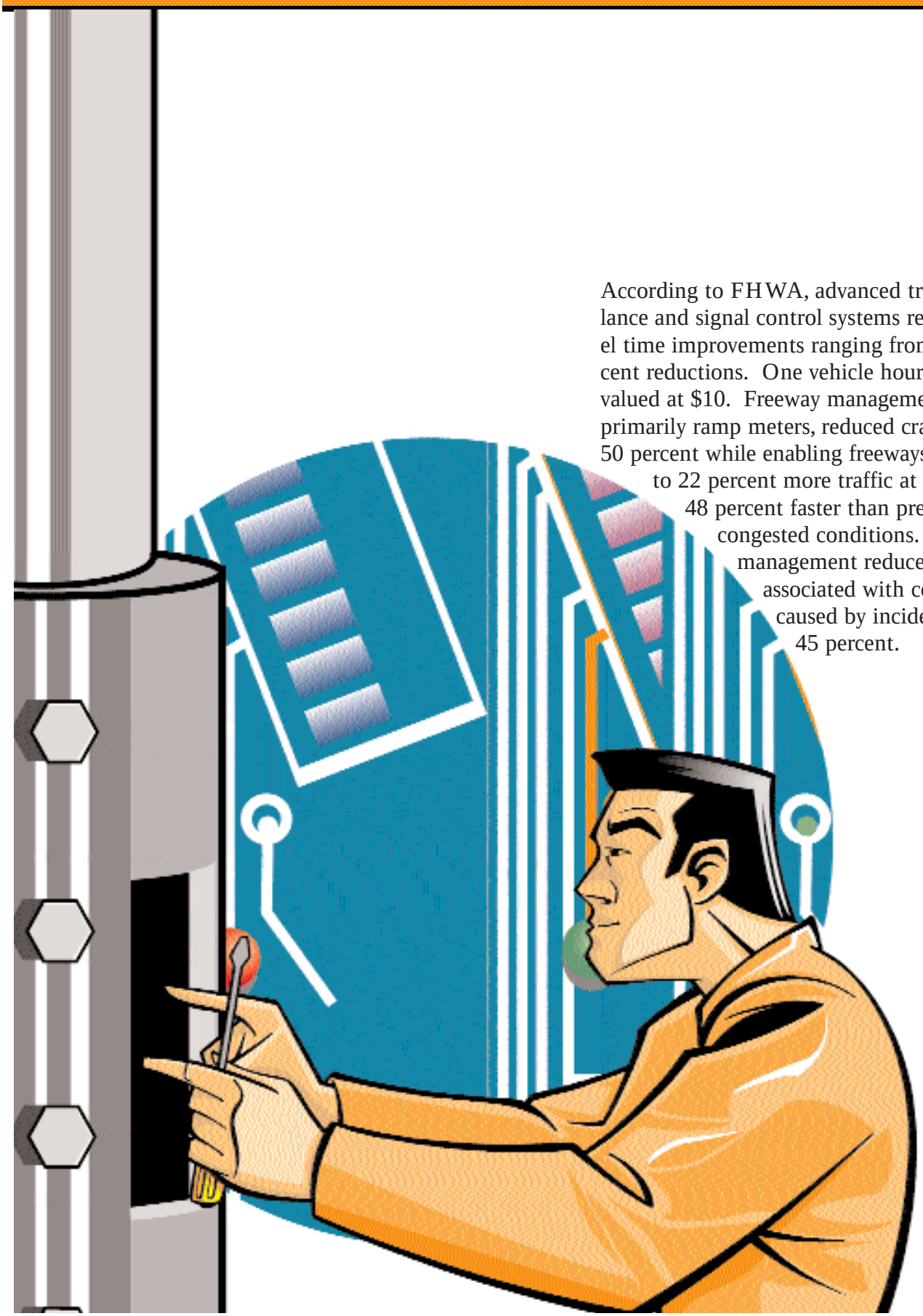
Signal timing is a powerful tool for moving traffic, and ITS enables rapid, effective signal timing changes. As long ago as 1988, evaluation of the implementation of new City "strategic" signal timing plans, which adjust the basic timing to fit prevailing day-to-day traffic conditions, showed delay reduced by 44 percent and vehicle stops reduced by 39 percent, under far less congested conditions than today. An April 2003 consultant report, "[Scottsdale] Indian School Road Corridor Intelligent Transportation System Evaluation," found that travel time through the 3-mile stretch was reduced by up to 64 seconds per vehicle.

ITS also offers significant staff savings in signalization engineering. In the past, new or improved signal timing plans were scheduled to be generated every two years for specific primary corridors. The signal analyst would visit the signal site, assess conditions, design a signalization scheme, install it, and revisit the signal to determine efficacy. This process could take days. CCTVs and the networked signals provide TMC staff the capability to adjust timing plans remotely. This greatly reduces the need for staff to drive the corridors personally, make manual timing changes, and then re-drive the same corridors for several days to make further adjustments. The consultant evaluation of Scottsdale ITS found that the technology potentially doubles the annual staff output of strategic timing changes, to 100 from 50.

In addition to strategic timing plan changes, with full implementation of Scottsdale's ITS infrastructure, staff will be able to monitor and adjust traffic flow real time from the TMC. The Indian School Road evaluation found that with ITS, each analyst conceivably could perform 400 or more real-time signalization changes annually.

The consultant evaluation further estimated that with ITS, the Scottsdale Police Department saved the equivalent of 30 traffic control officers during the Barrett-Jackson Classic Auto Auction and the Phoenix Open. A uniformed officer worked in the TMC during the event. These Police Department resource savings were evaluated at 2,976 staff hours at $36 an hour, or $107,136. Special events occur annually in Scottsdale.

ITS benefits can be significant. On a national level, FHWA documented benefits from implementing local ITS. Studies showed that investing in metropolitan infrastructure would yield an $8 benefit for every $1 invested. Benefits could range from measurable congestion reduction and reduced crash rates, to better relationships among service providers and a stronger national economy through increased mobility and new markets for products and services.



According to FHWA, advanced traffic surveillance and signal control systems resulted in travel time improvements ranging from 8 to 25 percent reductions. One vehicle hour of delay is valued at $10. Freeway management systems, primarily ramp meters, reduced crashes by 24 to 50 percent while enabling freeways to handle 8 to 22 percent more traffic at speeds 13 to 48 percent faster than pre-existing congested conditions. Incident management reduced delay associated with congestion caused by incidents by 10 to 45 percent.

Basic ITS Services

Scottsdale traffic management strategy in the 2003 environment is to take action quickly, and remotely, in response to changing traffic conditions by:

- Engineering and installing 18-mode signalization plans to permit pre-programmed traffic responses.
- Adjusting traffic signal timing in response to construction, incidents, special events and traffic volume changes that are perceived by means of City permits, CCTVs, Police Department radio, or phone calls.
- Relaying information to emergency responders.
- Diverting or advising travelers using VMS.

Specific functions are discussed in the following paragraphs.

Signalization with ITS Tools

Timing and coordinating the City's 260 traffic signals is the core technology of advanced traffic management. Signal timing is evaluating and loading appropriate timing plans into the signals, and signal coordination is linking the corridor signals to achieve the maximum safe progression. The responsibility to time and coordinate Arizona traffic signals solely rests on local jurisdictions that install and maintain their jurisdiction's traffic signals. TMC operations include periodic signal timing updates and real-time signal timing changes in response to continual monitoring of traffic throughout Scottsdale. TMC staff devise signal algorithms that are tailored for particular traffic patterns, based upon past volume data and the time of day. These 18 signalization schemes are programmed into each of the City's centrally controlled signalized intersections. These types of signal timing changes are intended to create basic timing plans to fit prevailing daily conditions as closely as possible. City ATMS signal control communicates with each traffic signal one time per second to verify that the correct timing plan is working at each intersection.

Other ITS devices provide data about roadway conditions to TMC operators. Decisions can be made on the basis of the data, and operators can change signal timing, moving from one of the 18 signal plans to another to relieve congestion. Further, ITS devices permit confirmation that the timing change was effective in reducing delays on the roadway segments via CCTVs and vehicle detection devices.

Incident Response with ITS Tools

A primary goal of the TMC staff during an incident on the roads is to relieve traffic congestion by adjusting signal timing, posting pertinent "real time" traffic information on VMS and broadcasting traffic information via radio or local media. ITS staff estimate that TMC acts on 700 to 800 incidents annually, from minor accidents to special events.

When an incident has been detected, staff respond first by assessing the nature of the problem. Assessment may be by CCTV view, if the location is covered, or by dispatching traffic or other nearby staff. If TMC staff can mitigate delay through signal timing changes or coordination with other agencies, staff will do so. The goal is to reroute traffic away from the incident.

In 2003, 60 loop detection stations exist that can detect delay by sensing how long a vehicle has been standing over the loop. Transportation staff are investigating software that would run detection algorithms on the detection station data feeds and sound an alarm when a delay has been detected. This function would serve as an adjunct to staff monitoring of CCTVs and police radio. ITS staff can then evaluate the appropriate response based upon the type of incident detected.

Managing Special Event Traffic with ITS Tools

Special events occur during the winter months in Scottsdale. Events include the Phoenix Open, car shows, horse shows and other events that draw large crowds. In 2003, for example, the National Collegiate Football Championships were held in Tempe, with both teams staying in Scottsdale. Moving the teams through town required a high level of security and transportation coordination between the Police Department and TMC staff. TMC staff were able to observe the progression of the teams through Scottsdale via the signal status map on the video wall. Police officers used ITS signal preemption devices to smoothly move the caravan through.

Planning for TMC Operations

By contrast to City capital infrastructure planning, limited planning has been performed for operations and maintenance of the ITS infrastructure being deployed. Attention has been focused on getting infrastructure built. Now that devices are coming on line, the Scottsdale ITS Strategic Plan is a step toward strengthening operational planning.

By 2006, as Service Area Plans and capital projects are implemented, the TMC personnel budget should rise from $208,710 at present, to $639,956 in 2006, as staff levels rise from 3 to 7 for the current 12-hour 5-workday shift. By 2009, when ITS infrastructure is built out, plans call for 9 staff.

As more ITS devices come on-line and service levels rise, additional TMC staff will be required for the City to realize the benefit of its infrastructure investment. According to the MAG Regional Concept of Transportation Operations, Technical Memo 5 and 6, traffic management operations consists of three basic components: 1) TMC, 2) preventive and response maintenance, and 3) incident management response.

Additional TMC operating hours will require other shift configurations of essential personnel. Sources of funds for program operation will need to be identified and requested during the annual City budget process. However, as is the case for technology planned by Information Systems, planning for ITS operations and infrastructure should progress at the same time to achieve the maximum efficiency and effectiveness for City resources.

TMC Operations - 12-hour / 5-day Shift	2003	2006	2007
Staff	3	7	9
Personnel Costs	$208,710	$639,956	$905,189

Current TMC Operations

In 2003, TMC operates 12 hours a day during business days when City offices are open. A majority of timing changes and traffic monitoring occur during the peak traffic hours of the day, 7 to 9 am, and 4 to 6 pm on weekdays. Typically, one or more staff monitors the CCTVs and police radio channels throughout the day, responding to incidents and events. During special events or serious incidents, TMC remains open. For example, during the application of rubberized asphalt on the Pima Freeway in Fall 2003, TMC staff worked around the clock on the weekends that the freeway was closed in order to mitigate the resulting congestion on Scottsdale streets. TMC staff also may be on-call.

The three TMC staff are responsible for:

- Creating new signal timing plans and modifying 18 existing timing plans;
- Responding to citizen concerns and requests regarding traffic signal timing;
- Monitoring existing ITS equipment to detect and mitigate traffic congestion;
- Managing incidents and accidents on City streets;
- Inputting data into the regional Roadway Condition Reporting System;
- Diagnosing and repairing minor problems with infrastructure;
- Providing traffic information on existing VMS and to news media;
- Planning and implementing the City's Capital Improvement Plan for ITS;
- Administering contracts for engineering, analysis, and maintenance;
- Representing the City at regional bodies such as MAG;
- Planning and budgeting for operations.

In addition to TMC staff, other staff also support traffic management. Traffic Engineering staff perform LOS studies and administer barricade permits in City rights-of-way. City Traffic Signal crews respond to signalization equipment problems. Traffic signal crews also provide routine preventive maintenance for the traffic signals. Police Department officers help to operate TMC during special events. City Information Systems staff provide advice and assistance related to technology and communications. Contractors provide maintenance and repairs for software, hardware and communications on an on-call basis. As well, contractors provide engineering design and evaluation expertise.

Plans for TMC Staff from Now Through 2009 Build-Out

TMC staffing is determined by kinds and levels of services desired, and by numbers and kinds of ITS devices. Plans are that by build-out of ITS infrastructure in 2009, Scottsdale TMC staff will consist of 9 fulltime personnel, compared to the 3 working in 2003. Ultimate staff for the program will include, for a 12-hour shift during a 5-day workweek:

Scottsdale TMC Position Function	Actual June 2003	Planned June 2006	Planned June 2009
Management/supervision	.5	1	1
Signalization/system planning	.5	1	1
Incident management	.25	1	1
System operators	1.25	2	4
Technician	.5	2	2
Total Staff	3	7	9

TMC Staffing Model

The Maricopa Association of Governments (MAG) updated the ITS strategic plan for the region in 2003. The Strategic Plan Update provides a sample staffing plan and budget for operations in the Scottsdale TMC. Scottsdale's TMC, in a regional context, falls within the parameters of a large TMC because of the number of ITS devices already deployed.

The MAG Strategic Plan recommended that for a large TMC with incident management, operating more than 700 devices on a 12-Hour, 5-Day Schedule, seven fulltime staff would be needed, as shown below. In addition, according to MAG's resourcing model, 1.5 fulltime staff are suggested to manage and operate a SMART corridor. City plans are that at build-out, three SMART corridors will be operating. Further, MAG suggests that the regional Roadway Condition Reporting System envisioned by AZTech would require one fulltime staff to manage and operate, once the Scottsdale TMC begins to offer the service.

Traffic Management Center with Incident Management Service-Positions	**MAG Recommended Staff**
Program/TMC Manager	1
Shift Manager/Supervisor	1
System Operator	2
Software Programmer	1
Communications Technician	1 (note 1)
Technician	1
Public Safety Liaison	0
Administrative Support	0
IT Manager	0
Traffic Analysts	As needed [discussed below]
Total TMC Staff	7

Source: Maricopa Association of Governments Regional Concept of Transportation Operations Technical Memorandum Number 5 and 6, 2003.

Note 1: The MAG staff model for a large TMC lists a software programmer as one position. In lieu of the programmer, Scottsdale's TMC would devote fulltime resources to signalization.

Types of functions that could be performed by TMC personnel, according to the MAG Plan, include activities shown in the table below:

TMC Functional Descriptions	Responsibilities
Traffic signal engineering	Adjusts traffic signal system timing parameters and uses models to optimize flow on a system of traffic signals.
Program management and development	Engineer, plan and develop projects that support ITS operations, and the concept of operations; interagency liaison; develop interagency agreements; monitor system performance and modify operational strategies; identify needs for new ITS services or technologies.
Control Center Technician	Electronics technician junior to the communications specialist, but who has training in maintenance of digital electronic equipment, particularly micro processors; identify hardware failure and make repair/replace decisions; troubleshoot and test electronic equipment and systems.
Communications technician	Electronics technician trained in the operations of variety of wireline, wireless technologies, and radio communications systems supporting video, data, and voice transmissions; responsible for on-going maintenance of systems.
System administrator	Responsible for user access management, communications configuration, configuration management, system upgrades, off-the-shelf software testing, installation; user support.
System operator	Operate the system; notify emergency response agencies, system maintenance staff, and other outside agencies; computer literate; familiar with operating commands of different systems.
Shift supervisor/manager	Well-developed judgment; distinguishes between situations that can be handled by TMC or those which require other agencies' participation; develops the operating plan; oversees system operators.
Operations center director	Overall responsibility for the TMC. Competent engineer, with management skills. Plans, budgets and controls for all fiscal matters. Manage and direct TMC personnel.

Source: Maricopa Association of Governments Regional Concept of Transportation Operations Technical Memorandum Number 5 and 6, 2003.

Signalization Resources

Traffic analysts are labeled "as needed" in the MAG model because the model incorporates contracting for signalization plans and updates that Scottsdale TMC staff perform themselves. Literature reviewed for the Scottsdale ITS Strategic Plan cited a metric used by the City of Menlo Park, California. The metric suggests that for the number of signals operated in Scottsdale (260), 2.5 traffic engineers would be needed. At present, one traffic engineer devotes half of his time to signalization, aided as available by two other Transportation traffic engineers who mainly work on other priorities.

Currently, Scottsdale's goal is to review signalization along major corridors every two years. The biennial review is in accordance with the adopted MAG goal for the region. By contrast, FHWA sets out a suggested standard for signals that signalization plans for major roadways should be evaluated every year.

Signalization optimization reviews are costly. Various cost models surveyed for the Strategic Plan showed a range of costs of contracted signalization. MAG estimates contractor cost at $1,200 per signal evaluated. The FHWA metric is that TMC managers should plan $2,400 a year for each intersection evaluated to update timing plans using consultants. The Washington DC-area Metropolitan Planning Organization reported $3,500 per signalization optimization.

ITS Operator Position to be Proposed

A total of an estimated 82 CCTVs are on the City capital budget for fiscal years 2003 to 2009. Based upon experience, TMC staff has determined that up to 12 CCTV-equipped intersections can be monitored and controlled effectively during the peak hours of the day by each ITS operator. Coverage assumes that no accidents have occurred in the area that would take staff attention away from the monitored intersections. In the event of an accident, operators would have to concentrate efforts to clear the accident scene by adjusting signal timing and notifying appropriate police officials. At full build-out of 82 CCTVs, 7 staff are estimated to be required for ITS operators during peak hours. Four staff would be fulltime operators and three staff would work during peak traffic hours.

Near-term plans are that one new ITS operator position will be proposed for the TMC, by December 2003, in addition to the ITS analysts and technician. The ITS Operator will be required to make the most effective use of 31 new CCTVs planned for installation by January 2004. The position of ITS Operator will serve several functions. First, the ITS operator will monitor the video wall and mitigate traffic congestion through manipulation of signal timing and notification of the Police Department and others about incidents. Second, the position will also be responsible for creating new signal timing plans, which in turn will provide better traffic progression, decreasing driver delay. In addition, the position will create a career path within the ITS field for City personnel to acquire new skills and abilities.

Shared Emergency Response Team

In addition to model TMC budgets, the MAG Regional Concept of Transportation Operations proposed an operating enhancement. MAG evaluated the operation and cost of a specialty form of incident management response team. The Team would be funded jointly by municipalities. Incident/emergency management specialty teams assist traffic management by setting up emergency lane/road closures, installing and maintaining signed detour routes, and providing directional information to motorists. A pilot project called Regional Emergency Action Coordinating Team (REACT) is underway in the West Valley to evaluate the concept.

Incident management response teams can be expensive to train and equip, as the function requires heavy trucks and barricades, among other items. Teams work 24-hour on-call schedules. Equipment required includes cellular phones, a dump truck, and a pickup truck with arrow. MAG estimates that Scottsdale's share of such a team would cost, annually, $535,400 for personnel, and $34,160 for the physical plant, a total of $569,560.

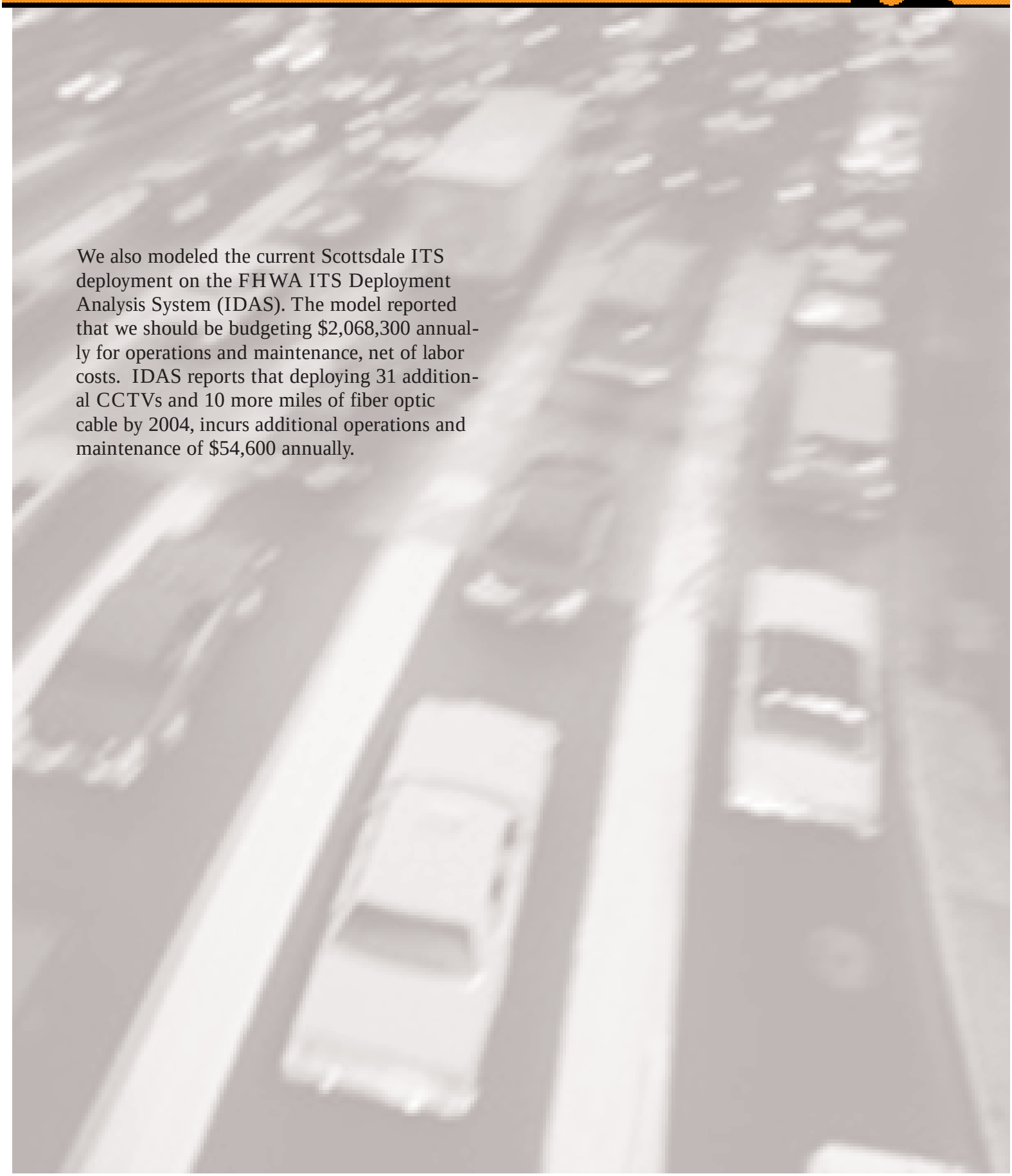
Other Annual Operating Costs

The fiscal year 2003/04 advanced traffic management operations and maintenance budget, net of labor costs, is $814,097, as shown below.

Cost Category	TMC 2003/04 Adopted Budget	Field Services [1] 2003/04 Adopted Budget
Contractual Services and utilities	$278,670	$359,673
Supplies and commodities	$16,000	$159,790
Total	$294,670	$519,427

Note 1: The 2003/04 $1,106,380 contractual services adopted budget is adjusted by deducting non-traffic signal contractual/utility expenses.
Source: City of Scottsdale FY 2003/04 Budget

Consultants for FHWA with whom we spoke suggest that an annual allocation equivalent to 15 percent of the infrastructure cost should be programmed for operation and maintenance of ITS infrastructure. The 15 percent does not include labor costs, but does include leases, repairs, replacements, and operating costs such as electricity. Since July 1, 1997, Scottsdale has invested approximately $5.2 million in ITS infrastructure and $1.7 million for traffic signals construction. Using FHWA's guideline, the total ITS operating and maintenance budget, net of labor costs, thus is predicted to be $1,030,135.



We also modeled the current Scottsdale ITS deployment on the FHWA ITS Deployment Analysis System (IDAS). The model reported that we should be budgeting $2,068,300 annually for operations and maintenance, net of labor costs. IDAS reports that deploying 31 additional CCTVs and 10 more miles of fiber optic cable by 2004, incurs additional operations and maintenance of $54,600 annually.

Communications and Utilities

The cost of ITS communications and utilities, about $465,000 a year of the total $815,000 other operating costs, is significant. The chart below shows types of communications employed and associated costs, in Scottsdale ITS in June 2003.

Scottsdale ITS Communications

Number	Type	Annual Cost	Use and Notes
252 lines	Telephone lines	$70 a month each line, or $212,000 annually, lease cost. $156,000 annual cost of signal electricity.	Traffic Signal Communication. Special-conditioned 4-copper wire lines leased from Qwest to carry low-speed data from and to all intersections with traffic signals. Backbone of the signal system to the TMC. Lines are always on. Number of lines varies as signals are added and removed. Telephone line leasing costs are paid from TMC cost center, and electricity costs are paid from Traffic Signals cost center.
6 lines	City-owned fiber	Annual cost for electricity is $1,530.	VMS. Fiber-optic installed on the Indian School Road corridor, to 6 VMSs.
2 lines	Telephone lines	$480 annual leasing cost.	VMS. Dial-up telephone lines leased from Qwest to communicate with 2 VMSs.
5 lines	Telephone lines	$50 a month each line, or $3,000 annual lease cost.	Video detection. Lines leased from Qwest to carry low-speed data from video detection devices. Connection must be established by dial-up (dialing the telephone). Video detection installed at 1) Scottsdale/Cactus, 2) Greenway-Hayden Loop/Frank Lloyd Wright Blvd., 3) Pima/Via De Ventura, 4) Scottsdale/Mayo, 5) Pima/Thompson Peak Parkway.
1 line	T-3 cable	$26,000 annual lease cost.	Computer server. Line leased from Qwest that serves to connect the AZTech server in the TMC to the McDOT Traffic Operations Center.
33 lines	T-1 cable	No cost. Would cost $200,000 annually.	CCTVs. Lines provided from Qwest free of charge as one component of the Qwest cable franchise agreement that expires in 2014. Connect CCTVs to the TMC.

Scottsdale ITS Communications (continued)

Number	Type	Annual Cost	Use and Notes
3 miles	Fiber optic cable	Indian School ITS corridor annual cable depreciation is $1,350,000 cost divided by 20-year life, or $67,500 annually.	Fiber optic cable installed in conduit. City-owned. Reduces reliance on leased telephone line facilities. Installed underground for Indian School Road ITS corridor in part with federal funds. $450,000 per mile for cable infrastructure. Fiber should have a 20-year life. Fiber must be City-maintained.
		Total annual cost is $464,800 for ITS components: $241,480 leasing cost; $67,500 depreciation cost for fiber; and $155,820 electricity cost.	

Planning for ITS Maintenance

High technology engenders a high cost for maintenance. High technology equipment life cycles are short. For ITS equipment that is installed outdoors, the situation is made worse by desert heat, monsoon storms, careless drivers who crash into ITS cabinets, or contractors who cut ITS fiber cable.

According to manufacturers, most City ITS equipment has a 5-year life span before replacement is required. Scottsdale experience has been that equipment has to be replaced before five years. Two City VMS, installed three years ago in 2000, have been repaired numerous times. CCTVs have a life span of just less than 3 years before replacement. Two CCTVs have been replaced twice, with the associated communications equipment, due to lightning. CCTVs are located at the top of existing signal poles and attract monsoon lightning.

The City's current approach to ITS maintenance is two-pronged. First, staff in the TMC plan and implement preventive and response maintenance for ITS devices other than signals whether devices are installed in the TMC or in the field. Under TMC oversight, CCTVs, VMSs, video detectors and other ITS devices are maintained by the contractors who installed them or by on-call contractors. TMC staff perform some limited front-end repair and diagnosis. Second, the Field Services Traffic Signal unit plans and implements preventive and response maintenance for the field traffic signal components of the traffic management system.

As of June 2003, except for traffic signals, maintenance and replacement for ITS infrastructure is not fully planned or budgeted. ITS equipment should be inventoried for safeguarding, for funding replacement, and to facilitate tracking of maintenance and repair histories. Budget should be earmarked to replace ITS equipment in the TMC or field. Earmarked budget would preclude eventual decline in service levels as more devices are deployed.

During the strategic plan process, Transportation Department staff initiated discussion with Financial Services about establishing a replacement fund for repairs and replacements. Staff from Traffic Signals and the TMC began meeting to define maintenance requirements and strategies. TMC staff initiated a project with Information Systems to implement bar code identification and tracking for ITS devices.

Maintenance Budget

The MAG Regional Concept of Operations provided a staff plan for maintenance of ITS field hardware that suggested Scottsdale should have 10 field staff for the number of devices it has. Scottsdale has over 800 ITS devices, mostly traffic signals. Field Services budgeted $580,521 in personnel cost for 8.5 traffic signal maintenance staff in fiscal year 2003/04. Adding an additional Field Foreperson to the Traffic Signal unit as indicated by the MAG model would cost, fully burdened at mid-range, $70,314 for fiscal year 04/05. Adding another half-fulltime-staff year would cost an estimated $20,000.

TMC Field Hardware	Current City Traffic Signal Staff	MAG Recommended Staff
Field Maintenance Personnel		
Field Foreperson	1	2
Field Technician	5.5	2
Field Electronics Technician	2	6
Total Field Maintenance Staff	8.5	10
Personnel costs	$580,521	$671,000

Source: City of Scottsdale FY 2003/04 Program Operation Budget, interview with the Traffic Signal Manager, and MAG Regional Concept of Transportation Operations Technical Memorandum No. 5 and 6, May 7, 2003.

Planning for ITS Infrastructure

ITS capital planning has been performed both in-house and by contracted engineering firms. The current capital plan for ITS was developed on a 5-year timeframe, to coincide with the 5-year programming horizon for the Scottsdale budget. A City project engineer defined projects and schedules, and prepared a map to illustrate the sequencing of ITS installations. Programming included consideration of other construction planned for the same times, to minimize disruption to the traveling public and conserve resources.

Planned ITS infrastructure consists primarily of fiber or conduit deployed in one of three ways, depending upon project-specific factors: fiber buried in PVC conduit, fiber installed in a storm sewer, or fiber strung aerially on utility poles. If fiber is to be installed on utility poles, poles will be leased from either Salt River Project or Arizona Public Service.

Updates to the ITS capital program were performed by the engineer quarterly, as projects became more highly defined, as available resources evolved, and as construction schedules changed. Construction costs were estimated based upon City experience.

As of June 2003, future ITS infrastructure that is planned includes:

- Three SMART (Systemically Managed Arterial) corridors on Hayden, Cactus and Shea;
- 200 loop, video, and radar detection devices;
- 40 additional VMS; and
- 27 additional miles of fiber optics cable and conduit, for a City-owned total of 30 miles.

Early plans envisioned the installation of 70 to 80 miles of City-owned fiber optic cable, at 10 miles per year, from the TMC to CCTVs at major intersections. Advances in wireless technology and use of free private provider fiber lines have enabled adjustments to the plan.

The Table below sets out ITS devices to be deployed from now until build-out in June 2009.

ITS Devices	DEPLOYED AS OF JUNE 2003	DEPLOYED AS OF JUNE 2006	DEPLOYED AS OF JUNE 2009
Traffic Signals	260	260	350
Traffic Signal Controllers	260	260	350
CCTVs	7	75	82
Video Detection Count Stations	21	41	41
VMS	8	37	48
SMART Corridors	0	1	3
Loop Detector Count Stations	60 stations	60 stations	60 stations
Wireless Devices	0	2	2
Radar Detector Count Stations	0	30	120
Traffic signal emergency vehicle preemption	190 intersections	190 intersections	190 intersections
Total Devices	806	956	1246

Benefits of City-owned Fiber Infrastructure

In addition to ATMS, the communications infrastructure is the backbone, and a major cost element, of the ITS system. Communications in 2003 consists of two components: telephone lines and fiber optic cable. The first component is leased telephone lines from private providers. The second is City-owned fiber optic cable.

The policy decision that the City should own and maintain fiber infrastructure for ITS in Scottsdale has far-reaching ramifications. As of June 2003, the City has 3 miles of fiber cable installed on Indian School Road, with an additional 10 miles of fiber and conduit under design. The installation of City-owned fiber optic cable with the Indian School Road ITS corridor project resulted in the annual cost avoidance of $40,248 annually. Indian School fiber avoided the need to lease communications. The Indian School Road fiber optic cable cost $450,000 per mile, for a total of $1,350,000.

The long-range capital plan for ITS, developed in the late 1990's, initially called for installation of 10 miles of conduit and cable a year up to a total of 70 to 80 miles of City-owned fiber. Plans in June 2003 are that 30 miles of fiber will be installed, as the City uses loaned lines from Qwest as well as wireless technology to complete the ITS. Fiber to be installed south of the Pima Freeway either is in the ground or already on the 5-year capital plan. Fiber to be installed north of the Pima Freeway has not yet been programmed. In addition, the cost of fiber installation has been value-engineered by City engineers, who plan installation in City-owned infrastructure such as storm sewers, or along utility poles.

Fiber moves more data longer distances than other media such as telephone lines. The term that describes the amount of data fiber can carry is “bandwidth.” Fiber also provides Scottsdale with greater internal capacity to support needs of other City facilities like the Corporation Yard, City parks and Libraries. Changing the equipment at each end of the fiber will allow expansion of Scottsdale's fiber communications, and greatly enhance the bandwidth of the fiber.

Other ITS Devices

CCTVs

CCTVs provide the TMC staff the capability to monitor and change signal timing remotely, and to monitor roadways for incidents, accidents and delays. By June 2003, seven CCTVs were installed in Scottsdale. Thirty-one additional cameras will be installed, for a Citywide total of 38 CCTVs. CCTVs are to be installed at intersections located south of Thompson Peak Parkway on free Qwest communications infrastructure, beginning January 2004.

The original plan for Scottsdale ITS required CCTVs to be installed at every mile on major and minor arterials. Placement would be based on covering approximately one mile in all directions from the site. This placement would provide visual coverage of every major roadway in Scottsdale. Each camera would be able to overlap the visual area of neighboring cameras.

Two CCTVs were operating as of January 2002. Five additional CCTVs began operating in August 2002 as part of the Indian School Road ITS Corridor. In June 2003, the network installed thus has 7 PTZs-1 at Frank Lloyd Wright and Scottsdale Road intersection, 1 at Frank Lloyd Wright and Hayden, and 5 along Indian School Road.

Count Stations

Video Detection

In the initial ITS Plan, CCTVs were to be supplemented with video detection cameras installed between major intersections at the mid-block points. The data received from video detection tells the engineers in the TMC approximately how fast vehicles are traveling and the volumes of traffic on that particular stretch of roadway. Video detection identifies vehicles through a method called “machine vision.” Cameras are aimed at the approaching vehicles, and as cars enter the detection area, a call is sent to the signal controller, letting the controller know that there are cars waiting for a green light.

By June 2003, City ITS will have 41 video detection cameras installed, including 12 installed as a part of the Indian School ITS corridor.

Loop Detector

At 60 intersections on major roadways throughout the City, traffic count stations are installed that provide information to traffic engineers about traffic volume on the roadway. Loop detectors are installed in the pavement in each lane on one side of the intersection. Loops are installed 300 feet from the intersection cross. Data on average speed and lane occupancy feeds continuously into ATMS at the TMC. There, ITS staff can access the data to assess the flow on the streets. Count stations supplement the work of staff that perform manual traffic counts and turning movement counts.

VMS

VMSs are electronic or mechanical display signs above the roads that traffic engineers control from the TMC. VMSs are planned for installation at least 2,000 feet prior to major decision points, or at major intersections. In addition to VMSs installed on the roads, plans are that the City also will own and maintain portable VMS on trailers that can be pulled and placed where needed. Messages displayed on the signs would inform drivers of downstream traffic conditions. For example, a VMS would be located one-quarter mile prior to the Scottsdale and Shea intersection, allowing drivers to read congestion messages and decide if they wish to continue on that route, or to use another street. The goal is to inform the driver of delays, accidents or incidents well in advance, and suggest alternative routing information.

In events where an accident has occurred or the lanes are blocked due to construction, an operator in the TMC can send information to the driver in real time, using the VMS, suggesting alternate routes. At a minimum, TMC staff can inform the driver of the nature of the delay if no alternate route is available. VMS can also inform drivers on Scottsdale streets of conditions on the Pima Freeway.

Emergency Vehicle Signal Preemption Devices

Emergency vehicle preemption allows police vehicles, fire trucks and ambulances to intervene in the normal operations of traffic control systems using wireless communications installed on traffic intersections and emergency vehicles. As the emergency vehicle approaches the intersection, the traffic signal controller recognizes it, interrupts the normal cycle, and changes the signal to green to allow progression. Scottsdale has emergency vehicle preemption devices installed in 190 intersections. Staff believe that the coverage is adequate for some time to come.

ITS Deployment Configuration to Change

The ITS Advisory Board during preparation of the Strategic Plan considered two policy directions that will affect the ITS configuration: 1) the migration of communication to become compatible with City local area networks, thus offering economies of operation as well as public service enhancements, and 2) the piloting of wireless communication.

Migration to Ethnernet Processing

TMC and Information Systems staff recommended to the Board that ITS migrate to Ethernet video processing. Ethernet is the City's open systems standard and the most widely used communication mode for local area networks. Basically, ITS would move from being a closed circuit television system, to a local area network computer system, with video feed from the traffic cameras.

When City ITS was first designed, Ethernet communication mode was not an option. Now, Ethernet equipment is becoming more economical. The City has not progressed so far in installing ITS that migration to Ethernet is cost prohibitive. Staff estimate that the migration will cost $150,000 for purchase and installation of new TMC software and hardware. The majority of costs probably will include retrofitting existing traffic signals, and purchasing the new Ethernet compatible signals in the future. An offsetting potential cost savings is that a move to Ethernet may help avoid the current $220,000 annual cost of Qwest traffic signal lines.

Moving to an Ethernet format would allow for a sustainable system at an efficient cost. The City's current ITS video method is full-motion analog video, which requires expensive electronics at both the CCTVs and the TMC. Currently, this equipment has to be purchased as a sole-source item though one company. Converting to digital Ethernet video will allow several manufacturers to bid on equipment,

which should reduce cost. As well, migration will make the video easy to share among ADOT, Police and Fire, and other cities. Information Systems is evaluating the impact on its staff resources of committing to maintaining the Ethernet portion of the ITS. Information Systems will probably become partners in the network management system for ITS.

Migration to Ethernet will begin with installations of 31 video cameras in January 2004. Variable message signs and CCTVs already are capable of communicating via Ethernet mode. Traffic signals controllers are not. Traffic signal controller software will be changed. Within two years, most of the existing video will be converted to Ethernet by converting existing equipment in the TMC. Industry development of Ethernet-compatible signal controllers and central signal software systems is about two years away. Migration to Ethernet controllers can be done at the City's leisure as more systems become available.

Pilot Test for ITS Wireless Communication

TMC staff also recommended to the Board that a pilot test installation of wireless ITS communication devices be tried along Scottsdale Road from Indian Bend south to Indian School. The Scottsdale Road corridor was selected for a pilot of wireless technology because of its sensitive design requirements as a scenic corridor. Visual clutter is an issue. In addition, underground cable construction would disrupt traffic on the busy corridor.

Currently, the only means of obtaining the high bandwidth communications required for ITS video is the installation of City-owned fiber or the leasing of lines from Qwest communications. However, wireless devices are becoming more comparable to fiber in terms of data-carrying capacity, and devices are getting cheaper.

Wireless devices require line-of-sight installation, and may be subject to environmental interference. While this is a proven technology, line-of-sight studies must be performed initially to ensure good quality signals from radio to radio. Wireless communication may also present significant security issues, if not designed with safeguards in place.

Scottsdale ITS Relationship to the Regional and National Programs

Scottsdale ITS cooperates as one component of a regional traffic management system to enable motorists to move quickly throughout the Valley. Two regional bodies provide forums and guidelines, as well as resources, for local ITS, the MAG Regional ITS Committee and the AZTech Committee. In addition, the federal government provides incentives, research, funding and national coordination to ITS deployment. Each is discussed below.

MAG Regional ITS Committee

The MAG Regional ITS Committee is the policy body for Scottsdale regarding regional ITS planning. The Committee's primary role is to coordinate the planning of regional ITS infrastructure and to recommend regional investments in ITS. MAG also is the Phoenix-area Metropolitan Planning Organization for the purpose of federal grants. Regional ITS investments recommended by the MAG ITS Committee, if approved, appear on the regional Transportation Improvement Plan.

The MAG Regional ITS Committee consists of representatives from FHWA, ADOT, Arizona Department of Public Safety, Valley Metro, Arizona State University and twelve MAG member agencies, of which Scottsdale is one. The Committee recently updated the Strategic Plan and regional ITS architecture to guide ITS infrastructure investments and coordinate technology-based solutions in the region.

The MAG ITS Strategic Plan emphasized three key administration activities identified as essential to the effective and efficient deployment of ITS:

Formalize operating procedures-operating procedures should be formalized and documented, to promote the understanding of procedures and to ensure that procedures will be maintained over time.

Formally plan for management and operations-ITS improvements typically incur a greater proportion of their costs as continuing management and operating costs rather than up-front capital costs. ITS equipment also typically has a much shorter anticipated useful life than many traditional improvements and must be replaced upon obsolescence. The resource impact of deployment should be evaluated and documented to guide long-term management.

Enhance operating budget procedures-Full costs of ITS operating expenditures, replacement costs for ITS infrastructure, and incremental expansion costs should be evaluated and documented in a strategic and operating plan.

AZTech™ Committee

Another regional ITS group, AZTech™, is a voluntary consortium of federal, state and local agencies, and private sector partners within the Phoenix metropolitan area. In 1996, FHWA awarded a Model Deployment Initiative grant to the Phoenix area to assist in the deployment and integration of a model traveler information system. AZTech™ was created to deploy the system. Maricopa County Department of Transportation acts as the lead agency for AZTech™.

Phase I of the AZTech™ project installed two CCTVs and two VMS for Scottsdale in 1997. In addition, a computer server in the TMC connects to ADOT, for the purpose of Roadway Condition Reporting Services. Roadway condition reporting allows drivers to access valley road congestion information via a 511 phone number. The AZTech™ server and communication will also, in the future, enable traffic operators around the region to observe and manipulate CCTVs, and in some cases, even change traffic signals, in other neighboring municipalities.

The Federal Role

The federal ITS program is attempting to help metropolitan areas move quickly along an evolutionary path of advancing traffic management. In 1996, the Secretary of Transportation established a goal for deploying the Metropolitan ITS infrastructure in over 75 of the nation's largest regions by 2005. Rather than fund the infrastructure, the federal role was to encourage state and local governments to fund and implement ITS.

To assure the national potential of ITS is realized, FHWA serves as a technology and deployment incubator. FHWA established an ITS Joint Program Office to coordinate national ITS program activities, including the national ITS architecture and the National Transportation Communications for ITS Protocol (NTCIP), that provide a common framework for planning, defining and integrating ITS. The City's 1996 design for Traffic View (the early name for ITS Traffic Management) referenced the effects on City infrastructure of the decision to migrate toward NTCIP standardization, in requirements for additional communication capacity. Procurements for ITS capital infrastructure incorporate this consideration.

FHWA also promulgated the ITS Deployment Analysis System (IDAS), software that can be used in planning for ITS deployments. State, regional, and local planners can use IDAS to estimate the benefits and costs of ITS investments.

National implications for local ITS deployments include considerations from federal legislation. For example, the reauthorization proposal for federal transportation funds for 2003, the Safe, Accountable, Flexible and Efficient Transportation Equity Act of 2003, sets out a requirement for all states to develop statewide incident reporting systems within 2 years of passage. In the future, local governments could be required to have a data exchange system formatted to communicate with the states' incident management systems, but may not be eligible to receive federal funding to achieve this.